

Determinants of outcome in operatively and non-operatively treated Weber-B ankle fractures

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Abstract

Introduction Treatment of ankle fractures is often based on fracture type and surgeon's individual judgment. Literature concerning the treatment options and outcome are dated and frequently contradicting. The aim of this study was to determine the clinical and functional outcome after AO-Weber B-type ankle fractures in operatively and conservatively treated patients and to determine which factors influenced outcome.

Patients and methods A retrospective cohort study in patients with a AO-Weber B-type ankle fracture. Patient, fracture and treatment characteristics were recorded. Clinical and functional outcome was measured using the Olerud-Molander Ankle Score (OMAS), the American Orthopaedic Foot and Ankle Society ankle-hindfoot score (AOFAS) and a Visual Analog Score (VAS) for overall satisfaction (range 0–10).

Results Eighty-two patients were treated conservatively and 103 underwent operative treatment. The majority was female. Most conservatively treated fractures were AO-Weber B1.1 type fractures. Fractures with fibular displacement (mainly AO type B1.2 and Lauge-Hansen type SER-4) were predominantly treated operatively. The

outcome scores in the non-operative group were OMAS 93, AOFAS 98, and VAS 8. Outcome in this group was independently negatively affected by age, affected side, BMI, fibular displacement, and duration of plaster immobilization. In the surgically treated group, the OMAS, AOFAS, and VAS scores were 90, 97, and 8, respectively, with outcome negatively influenced by duration of plaster immobilization.

Conclusion Treatment selection based upon stability and surgeon's judgment led to overall good clinical outcome in both treatment groups. Reducing the cast immobilization period may further improve outcome.

Keywords Ankle · Fracture · Outcome · Operative · Non-operative

Introduction

Ankle fractures are one of the most common fractures encountered in the Emergency Department. They represent approximately 10% of all fractures [7] and previous studies suggest that their incidence is rising [8]. Currently operative treatment dominates the literature on ankle fractures; however, conservative treatment of stable ankle fractures is gaining more interest. Studies comparing operative and conservative treatment are dated and contradicted in their conclusions. For example, Makwana et al. [17] found superior outcome in patients over 55 years of age managed by open reduction and internal fixation (ORIF) compared with closed treatment. Beauchamp et al. [3], on the other hand, reported little difference in functional outcome after conservative or operative treatment of displaced ankle fractures in patients over 50 years of age. Table 1 summarizes the results of previous studies comparing the

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Table 1 Literature overview of studies comparing operative versus conservative treatment of ankle fractures

ankle fractures								
	Dietrich et al. [9]	P	57	23	34	49	17	–
	Makwana et al. [17]	RCT	43	22	21	>55	27	+
	Anand 1993 [1]	R	80	39	41	>60	28 (O), 25.5 (C)	+
	Rowley et al. [22]	RCT	42	20	22	16–70	5	=
	Bauer et al. [2]	RCT	92	43	49	50	84	=/early +
	Philips et al. [21]	RCT	71	45	26	41	42	+
	Beauchamp et al. [3]	R	126	71	55	>50	24	=
	Tunturi et al. [26]	R	239	124	115	46	36	= (Depending on radiological result)
P Prospective, R retrospective, RCT randomized controlled trial, SER# supination exorotation fracture, O ORIF, C conservative treatment, N.A. not available	Yde 1980 [29]	R	69	34	35	15–49	36–120	= (in SER2)
	Yde 1980 [30]	R	89	60	29	15–75	36–120	+ (in SER4)
	Eventov 1978 [12]	R	200	101	99	16–87	48	–
	Malka 1969 [18]	R	50	25	25	N.A.	19.4	=/+
	Wilson 1966 [27]	R	55	28	27	45.3	97	=

results of conservative and operative treatment of displaced ankle fractures.

The decision whether to operate or not is often based upon the Arbeitsgemeinschaft Osteosynthesefragen (AO) modifications of Weber's classification and the Lauge-Hansen classification [26], but is also highly dependent upon the surgeon's individual judgment on displacement. There is consensus that undisplaced Weber A-type fractures rarely require operative treatment, and that Weber C-type or grossly displaced fractures are unstable by nature and therefore require surgery. The gray area of treatment lies mainly with the minimally displaced Weber B-type ankle fractures.

The primary aim of this study was to determine the outcome of operatively and conservatively treated patients with an AO-Weber B-type ankle fracture. The secondary aim was to gain insight in various factors influencing outcome.

Materials and methods

Patients

All consecutive patients aged between 16 and 65 years, treated between January 2004 and July 2009, with a AO-Weber B-type ankle fracture were included in this retrospective study. Minimum follow-up was 6 months. Patient characteristics (i.e., age, gender, diabetes, and smoking habits), fracture characteristics (i.e., fracture side, displacement, AO-Weber fracture type [14], Lauge-Hansen classification [16] and number of malleoli involved), and

treatment characteristics (i.e., operative vs. conservative) were recorded from the patient files, operation reports, and the picture archiving and communication system (PACS: Kodak Carestream®). This study was performed with the approval of the local medical ethics committee.

Treatment protocol

Treatment was based upon patient characteristics (co-morbidities, level of activity), fracture characteristics (number of fractured malleoli, displacement, and stability) and on surgeons preference concerning the threshold of displacement of the distal fibular fragment and shortening of the fibula, which was usually at 2 mm. Most fractures were initially treated in a non-weight bearing plaster backslap and evaluated at the outpatient department within 1 week.

Conservative treatment concerned immobilization in a below-knee plaster cast usually for 6 weeks. During the application of the cast, a manual reduction was tried by reversing the trauma-mechanism using the Lauge-Hansen classification. Immediately after application of the cast at the Emergency Department, radiographs were taken to confirm that reduction was adequate. During the final 3 weeks, the patients were allowed partial or full weight bearing in the cast.

ORIF was performed according to the AO-guidelines under fluoroscopic control, and performed by residents under supervision of a staff member [16]. All patients received preoperative antibiotic prophylaxis (i.e., third generation cephalosporin). After surgery, the ankle was usually immobilized with a below-knee plaster cast for

6 weeks. Weight bearing in the cast was usually allowed after 2 weeks [24].

In both treatment groups, radiographs were taken at 2 and 6 weeks to ensure that there was no loss of reduction and to monitor fracture healing. During immobilization in plaster cast, all patients were treated with low-molecular-weight heparin, once daily, as thrombosis prophylaxis. After cast removal, patients commenced weight bearing under supervision of a physiotherapist.

Radiographic assessment

Radiographic data were obtained from the radiographs taken immediately after the injury and immediately after operative repair. A total of four of the pre-operative radiographs were missing rendering it impossible to classify these fractures. Dislocation was measured as lateral displacement of the fibula at the level of the tibial plafond and the distal anteromedial border of the fibula (Mueller nose), and at the Medial Clear Space (MCS) at 10 mm below the tibial plafond. Fracture classification according to AO-Weber and Lauge-Hansen was performed by two observers (ES, TS). In case of differences consensus was met after discussion. MCS and dislocation at the Mueller nose as measure of lateral displacement of the fibula were calculated on the same radiographs.

Outcome measurement

Outcome was measured using standard questionnaires, which was sent in January 2010, and consisted of the Olerud–Molander Ankle Score (OMAS), the American Orthopaedic Foot and Ankle Society ankle-hindfoot score (AOFAS), and a single question Visual Analog Scale (VAS) for patient satisfaction with outcome. A reminder was sent after 4 weeks.

The OMAS is a self-administered patient questionnaire with a score of zero (totally impaired) to 100 (completely unimpaired) and is based on nine different items: pain, stiffness, swelling, stair climbing, running, jumping, squatting, supports and work/activities of daily living [20].

The AOFAS ankle hindfoot score was introduced in 1994 by Kitaoka et al. [15], and includes nine questions on pain, activity and functional limitations, walking distance, difficulties with different terrains, gait abnormality, sagittal range of motion at the ankle and range of motion at the subtalar joint, stability, and alignment (whether or not plantigrade). The nine questions relate to three components: pain (one question; 40 points), function (seven questions; 50 points), and alignment (one question; 10 points) leading to a total possible score of 100 points. The question related to alignment and range of motion was completed by a physician based upon patient files and

radiographs; the other questions were completed by the patient.

A Visual Analog Scale was used to measure overall satisfaction of patients with outcome (range 0–10).

Statistical analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 16.0 (SPSS, Chicago, IL, USA). The Kolmogorov–Smirnov test was used to test the normality of the numeric data. The Levene's test was applied to assess homogeneity of variance between data. Since most numeric variables did not show normal distribution or equal variance, all items were regarded as nonparametric for the statistical analysis. Mann–Whitney *U* tests were performed to assess statistical differences in OMAS, AOFAS and VAS scores between subgroups. Numeric data are expressed as medians with P_{25} – P_{75} ; categorical data are shown as numbers with percentages. Logistic regression models were developed to correct for gender, age, diabetes, smoking habits, BMI, fracture-type, and fracture-dislocation. A *p* value <0.05 was taken as level of statistical significance.

Results

Baseline characteristics

A total of 185 (response rate 71%) out of 261 approached patients returned the questionnaire; 82 patients were treated conservatively (response rate 69%) by immobilization in a plaster cast and 103 patients had undergone surgical treatment (response rate 72%). Table 2 shows the baseline characteristics of the two groups. Most patients were female (61.1%), and the median age at trauma was 50.6 years. The median follow up time was 46 months. Baseline characteristics were similar in both groups, with duration of plaster cast immobilization being the single exception. Almost all patients were immobilized in a plaster cast (96.8%), 94.2% in the operatively treated group and 100% in the conservatively treated group ($p = 0.035$).

In the conservatively treated group the median age was 50.1 years, median FU 49 months. Diabetes was present in 6.1% of the patients and 26.8% had a smoking habit. In 40.2%, the right ankle was fractured. Immobilization in a plaster cast was for a median of 6 weeks (P_{25} – P_{75} , 6–8 weeks).

In the operatively treated group the median age was 50.7 years, median FU 43 months. Less people (19.4%) were smokers compared to the conservatively treated group. The right side was involved in 51% of the fractures. The syndesmosis was injured in 16 cases (15.5%).

Table 2 Baseline characteristics

P values <0.05 are considered statistically significant

Data are shown as ^a numbers with the percentage between brackets or as ^b median with the P₂₅–P₇₅ given between brackets

Data are analyzed using a ^c Chi Square analysis or ^d Mann–Whitney *U* test

	Total	Conservative	Operative	<i>p</i> value
<i>N</i>	185	82	103	
Males ^a	72 (38.9)	33 (40.2)	39 (37.9)	0.763 ^c
Age (years) ^b	50.6 (37.9–58.7)	50.1 (35.7–58.2)	50.7 (41.1–60.5)	0.258 ^d
BMI (kg/m ²) ^b	25.5 (23.2–28.7)	24.8 (22.8–28.3)	26 (23.9–29.4)	0.098 ^d
Right side affected ^a	97 (54.4)	44 (53.7)	53 (51.5)	0.770 ^c
Cigarette smoker ^a	42 (22.7)	22 (26.8)	20 (19.4)	0.289 ^c
Diabetes ^a	11 (5.9)	5 (6.1)	6 (5.8)	1.000 ^c
Follow-up (months) ^b	46 (31–62)	49 (33–64)	43 (29–60)	0.155 ^d
Cast immobilization ^a	179 (96.8)	82 (100)	97 (94–102)	0.035 ^c
Immobilization (weeks) ^b	6 (6–8)	6 (6–8)	6 (6–8)	0.412 ^d

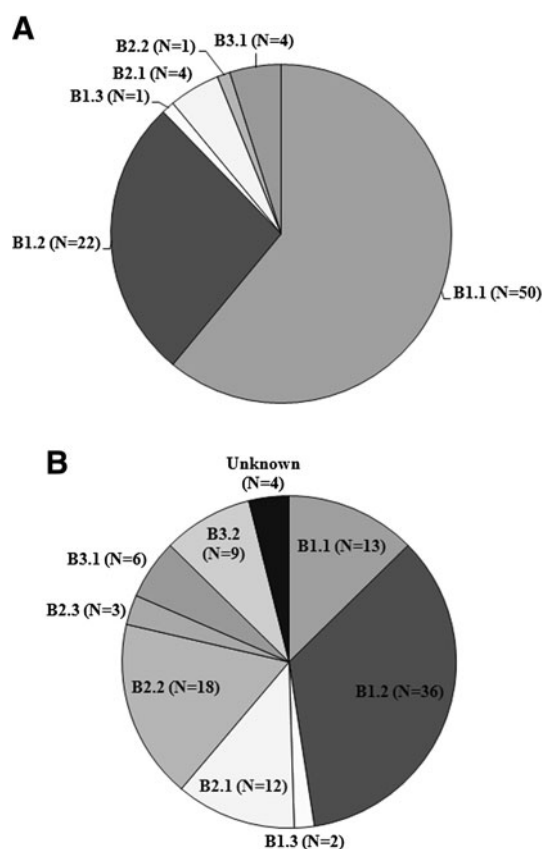


Fig. 1 Fracture type distribution as classified according to AO-Weber; **a** conservatively treated patients, **b** operatively treated patients

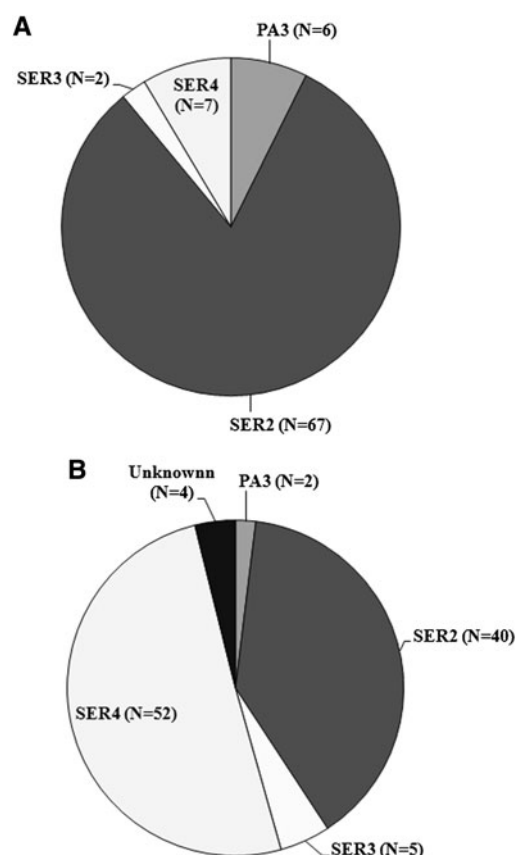


Fig. 2 Fracture type distribution as classified according to Lauge-Hansen; **a** conservatively treated patients, **b** operatively treated patients

Radiographic data

Radiographic results were determined per treatment modality (Figs. 1, 2; Table 3). In the conservatively treated group, most fractures involved were type AO-B1.1 (61%) and LH-SER2 (81.7%). In 92.7%, there was only unimalleolar involvement. The median fibular dislocation was 0 mm. In the operatively treated group most injuries were type AO-B1.2 (35%) and LH-SER4 (50.5%) fractures. Fibular displacement was frequently a reason for ORIF (median 1.39 mm).

Outcome measurement

In the conservatively treated patients the median OMAS score was 93 points, AOFAS score was 98 points, and the VAS score was 8 points. The operated patient group reported a median OMAS, AOFAS, and VAS score of 90, 97, and 8 points, respectively.

Spearman rank correlation showed a statistically significant inverse correlation between BMI and outcome for

Table 3 Radiographic findings

	Variable	Total	Conservative	Operative	<i>p</i> value
<i>P</i> values <0.05 are considered statistically significant <i>MCS</i> Medial Clear Space, <i>N.A.</i> not applicable Data are shown as ^a numbers with the percentage between brackets or as ^b median with the <i>P</i> ₂₅ – <i>P</i> ₇₅ given between brackets Data are analyzed using a ^c Chi Square analysis or ^d Mann–Whitney <i>U</i> test	Malleoli involved ^a				
	Unimalleolar	145 (78.4)	76 (92.7)	69 (67.0)	<0.001 ^c
	Bimalleolar	23 (12.4)	4 (4.9)	19 (18.4)	
	Trimalleolar	17 (9.2)	2 (2.4)	15 (14.6)	
	Luxation ^a	12 (6.5)	0 (0)	12 (11.7)	<0.001 ^c
	Pre-operative				
	MCS (mm) ^b	2.85 (2.26–3.90)	2.53 (2.19–3.06)	3.66 (2.32–5.93)	<0.001 ^d
	Fibular displacement (mm) ^b	1.08 (0.00–1.83)	0.00 (0.00–1.48)	1.39 (0.66–2.38)	<0.001 ^d
	Post-operative				
	MCS (mm) ^b	2.58 (2.16–3.12)	N.A.	2.58 (2.16–3.12)	N.A.
	Fibular displacement (mm) ^b	0.00 (0.00–0.43)	N.A.	0.00 (0.00–0.43)	

both groups. Higher BMI correlated with a worse functional outcome as shown for the AOFAS (Spearman rank correlation coefficient $R_s = -0.249$, $p = 0.001$), OMAS ($R_s = -0.210$, $p = 0.005$), and VAS ($R_s = -0.229$, $p = 0.002$).

Multivariable analysis of the conservatively treated patients (Table 4A) showed that an increase in age had an inverse affect on the OMAS, a fracture of the right side gave a lower AOFAS, an increase in distal fibular displacement measured at the Mueller nose resulted in a lower VAS, a higher BMI gave a lower AOFAS, or a longer period of cast immobilization had a significant negative effect on the OMAS. Multivariate analysis of the operatively treated patients (Table 4B) showed that an increase in plaster immobilization gave a worse result on the OMAS and AOFAS score.

No significant correlation could be detected between the number of malleoli involved, smoking or diabetes and functional outcome in both groups.

Discussion

The aim of this study was to determine the outcome of operatively and conservatively treated AO-Weber B-type ankle fractures, and to gain insight into the factors affecting outcome. The data revealed that the degree of fibular displacement played a significant role with respect to the decision whether to operate or not. This is reflected in the finding that most AO-B1.1 and SER-2 type ankle fractures (without fibular displacement) were treated conservatively with a below-knee cast for 6 weeks. These results are in agreement with the results of Beauchamp et al. [3] and Yablon et al. [28], who concluded that reduction and stable fixation of the lateral malleolus is the key in internal fixation. Functional outcome in this group was good, with a median OMAS score of 93 points, AOFAS score of 98

points, and VAS score of 8 points. Good outcomes were also seen in the study of Dietrich et al. [9], who found that functional treatment of stable Weber-B fractures appeared to be superior to surgery.

Only four randomized trials comparing operative treatment with closed reduction and casting have been published [2, 17, 21, 22]. No significant differences in functional outcome between the two treatment regimens were reported in any of these studies; however, there was a significant loss of follow up in the studies of Philips et al. [21] and Makwana et al. [17]. Bauer et al. [2] showed no difference at the long term between patients treated surgically or by closed reduction and casting, but the surgical group recovered quicker. Rowley on the other hand, found that surgically treated patients took longer to recover normal movement and gait [22]. Philips showed better radiological outcomes in operatively treated patients, but the clinical outcomes were the same in both groups [21]. Makwana et al. [17] showed functional advantage for operatively treated patients.

The findings above suggest that stable fracture might be treated well conservatively. However, unstable fractures fare better with operative treatment [13, 23]. In the current study, operatively treated patient group, most ankle fractures were of the Weber type b1.2 and unstable Lauge-Hansen type SER-4. All ankle fracture-dislocations were operated on. Functional outcome in this operated group was similar to the conservatively treated patients, with a median OMAS, AOFAS, and VAS score of 97, 90, and 8 points, respectively. This data would suggest that if there is minimal displacement of the distal fibula conservative management is acceptable in stable ankle fractures. ORIF would be indicated for unstable, displaced ankle fractures. This is in agreement with previous reports by Michelson and by Burwell et al. who showed that accurate reduction and fixation of ankle fractures led to a rapid return of function [6, 19].

Table 4 Multivariable analysis of factors influencing outcome in patients treated A conservatively or B operatively

Variable	OMAS		AOFAS		VAS	
	Beta (95% CI)	P	Beta (95% CI)	P	Beta (95%CI)	P
A Conservatively treated patients						
Follow-up duration	0.021 (−0.184; 0.220)	0.859	0.112 (−0.117; 0.333)	0.341	0.114 (−0.012; 0.034)	0.344
Age	−0.288 (−0.621; −0.044)	0.025	−0.152 (−0.518; 0.123)	0.224	−0.124 (−0.049; 0.016)	0.327
Gender	0.072 (−6.562; 11.257)	0.600	−0.060 (−12.107; 7.713)	0.443	0.0522 (−0.814; 1.193)	0.708
Affected side	−0.198 (−13.876; 1.108)	0.094	−0.241 (−17.109; −0.442)	0.039	−0.170 (−1.460; 0.228)	0.150
Number of malleoli	−0.206 (−18.053; 0.941)	0.077	−0.149 (−17.693; 3.677)	0.195	−0.113 (−1.616; 0.562)	0.338
Pre-MCS	0.098 (−4.034; 8.878)	0.456	−0.019 (−7.007; 6.662)	0.886	0.020 (−0.672; 0.783)	0.879
Pre-Mueller	−0.209 (−8.129; 0.662)	0.095	−0.212 (−9.160; 0.618)	0.086	−0.276 (−1.046; −0.055)	0.030
BMI	−0.179 (−1.222; 0.160)	0.130	−0.360 (−1.973; −0.436)	0.003	−0.215 (−0.149; 0.006)	0.072
Smoking	−0.217 (−16.314; 0.567)	0.067	−0.170 (−16.351; 2.425)	0.143	−0.086 (−1.302; 0.600)	0.464
Diabetes	0.029 (−14.646; 18.760)	0.807	0.076 (−12.458; 24.700)	0.513	−0.126 (−2.888; 0.875)	0.289
Immobilization duration	−0.371 (−4.476; −0.849)	0.004	−0.076 (−2.636; 1.398)	0.542	−0.247 (−0.403; 0.006)	0.057
B Operatively treated patients						
Follow-up duration	−0.089 (−0.324; 0.064)	0.513	−0.089 (−0.341; 0.173)	0.517	−0.005 (−0.022; 0.021)	0.972
Age	−0.073 (−0.436; 0.252)	0.595	−0.058 (−0.438; 0.287)	0.679	−0.096 (−0.041; 0.020)	0.489
Gender	0.065 (−6.895; 11.573)	0.614	0.164 (−3.601; 15.872)	0.212	0.056 (−0.639; 0.990)	0.668
Affected side	−0.141 (−13.503; 3.706)	0.259	−0.105 (−12.881; 5.264)	0.404	−0.145 (−1.202; 0.317)	0.249
Luxation	−0.087 (−52.265; 26.028)	0.505	0.086 (−27.743; 54.808)	0.515	0.184 (−1.006; 5.903)	0.162
Number of malleoli	−0.191 (−13.527; 1.593)	0.120	−0.229 (−15.361; 0.447)	0.064	−0.190 (−1.189; 0.145)	0.123
Pre-MCS	0.057 (−1.384; 2.091)	0.685	0.091 (−1.248; 2.415)	0.526	0.032 (−0.136; 0.171)	0.822
Pre-Mueller	0.141 (−1.612; 5.188)	0.297	−0.002 (−3.606; 3.564)	0.991	−0.02 (−0.322; 0.278)	0.883
Post-MCS	0.048 (−3.796; 5.659)	0.695	−0.08 (−6.583; 3.385)	0.524	−0.101 (−0.588; 0.247)	0.417
Post-Mueller	−0.158 (−15.490; 3.534)	0.214	0.066 (−7.412; 12.647)	0.604	−0.021 (−0.908; 0.771)	0.871
BMI	−0.209 (−1.921; 0.307)	0.153	−0.198 (−1.971; 0.379)	0.181	−0.187 (−0.162; 0.035)	0.202
Smoking	−0.039 (−12.991; 9.554)	0.762	0.091 (−7.645; 16.127)	0.478	0.125 (−0.505; 1.485)	0.329
Diabetes	0.042 (−16.665; 23.186)	0.745	0.129 (−10.613; 31.406)	0.326	0.133 (−0.857; 2.660)	0.309
Immobilization duration	−0.368 (−4.063; −0.515)	0.012	−0.375 (−4.307; −0.565)	0.012	−0.286 (−0.313; 0.001)	0.051

BMI Body mass index, *AOFAS* American Orthopaedic Foot Ankle Society ankle-hindfoot score, *OMAS* Olerud–Molander Ankle Score, *VAS* Visual Analog Scale, *MCS* Medial Clear Space, *pre-Mueller* dislocation of the distal fibular fragment pre-operative; *post-Mueller* dislocation of the distal fibular fragment post-operative

P-values printed in bold show statistical significant associations

Overall, age, affected side, fibular displacement at the ‘Mueller nose’, BMI, and immobilization duration negatively affected outcome in conservatively treated patients. In operated patients, only the immobilization duration was negatively associated with functional outcome. Similar results were shown by Ebraheim et al. [10], who found worse results in patients with a Weber type-C fracture who were treated with ORIF and obesity or diabetes. The latter could not be confirmed in the present study. Boddenberg [4] concluded that ankle fractures in patients with diabetes heal with a significant delay. In a study of Egol et al. [11], younger age, male gender, and absence of diabetes were predictive of improved functional recovery at 1 year following ankle fracture surgery. Our data do not support such a correlation between gender and diabetes with functional outcome as measured with the OMAS, AOFAS, or VAS. The number of

fractured malleoli did not affect outcome in the current study, compared with the results by Broos et al. [5].

The treatment protocol used in the current study is very similar to the protocol used in the other studies [9, 17, 24, 25]. Especially in the operative group, patients were left non-weight bearing for at least 2 weeks, depending on wound-healing. After this, patients were usually kept in a weight-bearing cast for approximately 4 weeks. The literature suggests that at 1 year the outcome after early and delayed exercises is similar, with higher wound complications in the early exercise group [24].

The main limitation of this study is its retrospective design. However, combining the results of this study with the literature review might lead to the conclusion that the non- or minimally displaced stable AO-B1.1 or SER-2 type fractures should be treated conservatively and the unstable

AO-B1.3–B3.3 and SER-4 should be treated operatively [13]. The difficulty lies in determining the best treatment option for the intermediate displaced distal fibular fractures (AO-B1.2). A randomized controlled trial would be necessary to determine the cut-off in displacement to be acceptably treated non-operatively.

The determinants of outcome used in this study were previously reported in the other studies for comparison purposes. The outcome scores used are frequently used scores for ankle fractures and other foot and ankle conditions. Combining three scores gave greater insight into the functional outcome of a large population of patients with an isolated Weber-B ankle fracture. Two observers independently classified the fractures and discussed the individual cases until consensus was met, to achieve the highest possible quality of data.

In conclusion, the current data show that when treatment regimen for Weber-B fractures is based upon dislocation of the distal fibular fragment and fracture type (AO-Weber and Lauge-Hansen), the overall outcome per treatment regime is good to excellent. Shortening the duration of cast immobilization could lead to improved outcome.

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